

MAGNETO SWITCH



By **BOB NUCKOLLS**

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The AeroElectric Connection
6936 Bainbridge Rd.
Wichita, KS 67226-1008

I was privileged to receive an invitation to speak before an annual gathering of RV builders in Frederick, Maryland, just before Sun 'n Fun. Several questions posed there illustrated a general misunderstanding about magneto switch wiring with respect to switches and wire to be used. After exploring the issues with attendees, someone suggested that this would be a good topic to write up for *SPORT AVIATION*. So here it is . . .

There are two types of switches commonly used to control aircraft magnetos and starters. The most popular is the key locking, multi-position, rotary switch like those found on many production aircraft. The other is a more toggle type switch not unlike those used to control devices like pitot heat or landing lights. Proper wiring of either switch is critical to the health and well being of your starter, engine and perhaps your body! Let's examine some background:

Magnetos are renowned for their weak spark, especially while the engine is cranking. Cranking rpm range from 60 to 150 depending on battery, wiring, starter and temperatures. The weak spark and generally rich mixture may combine to make starting an uncertain proposition. Another problem arises from the fact that magnetos are timed to deliver a spark at some point before top-dead-center. This timing is selected for proper engine performance while running; it is timed much too early for starting. Many aids to starting have been used on military, commercial and experimental aircraft; the most common of these is an impulse coupler. The impulse coupler is rather elegant in its simplicity, its popularity a testament to relative cost and reliability. However, in an assessment of potential problems with magneto switches, we

need to understand how impulse couplers work.

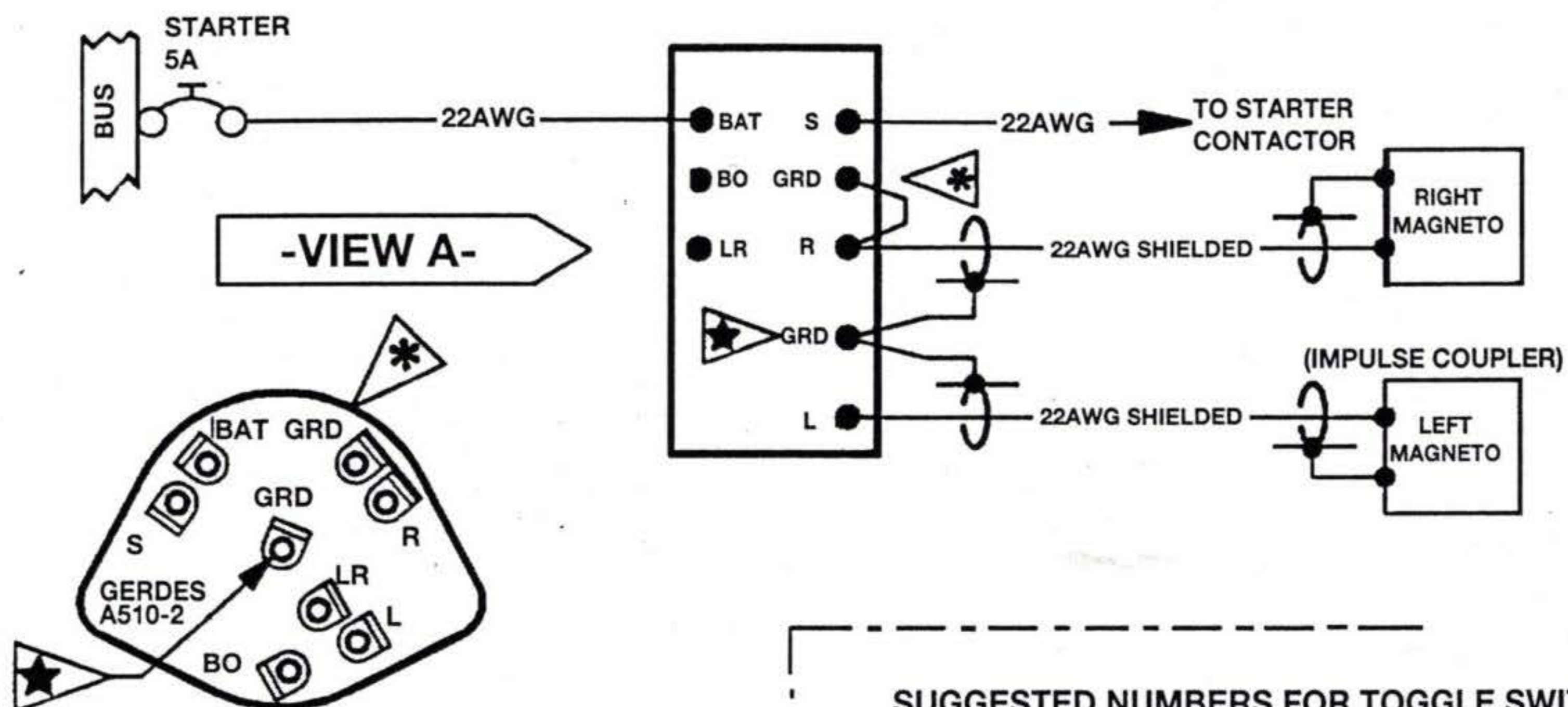
The impulse coupler is mounted in the drive train between an engine and one or both magnetos. The device contains springs, pawls, cams and flyweights which operate in the following manner. As the engine rotates at cranking rpm, a spring loaded pawl sticking out of coupler contacts a hardened stud embedded in the crankcase casting which literally locks the magneto shaft up solid. As the engine continues to rotate, a heavy spring inside winds up and a cam begins retracting the pawl. At some point just after top-dead-center on piston travel, the pawl retracts enough to allow it to slip off the locking stud. Energy stored in the spring snaps the magneto back into synchronization with the engine. Two beneficial things happen during this rapid "catch up" motion of the magneto shaft: the short pulse of higher velocity rotation enhances spark during a time when engine speed is too low to produce normal sparks from the magneto. Further, delayed mechanical release causes a spark to be delivered after top-dead-center thus ensuring the first explosion to occur in any cylinder pushes the engine forward instead of backwards. After the engine starts, flyweights inside the coupler pull against another spring to retract the pawl thus preventing further engagement with the locking stud. The energy storage spring used to "snap" the shaft during cranking now keeps the magneto in proper step with the engine for running.

It is common practice to install only one impulse coupler on the left magneto. Some engines have couplers on both mags but it is rare. If you want to know how many couplers are installed on your engine, make sure the mags are off . . . better yet, do this during maintenance when all the spark plugs are out of their holes. Turn the propeller shaft very slowly in the proper direction for run-

ning. You will hear a sort of clanking snap as the pawl cam releases the coupler two or three times per prop shaft rotation. It's almost impossible to get two magnetos timed so closely that they release at exactly the same time. Turn the shaft very slowly and listen for two, closely spaced "snaps."

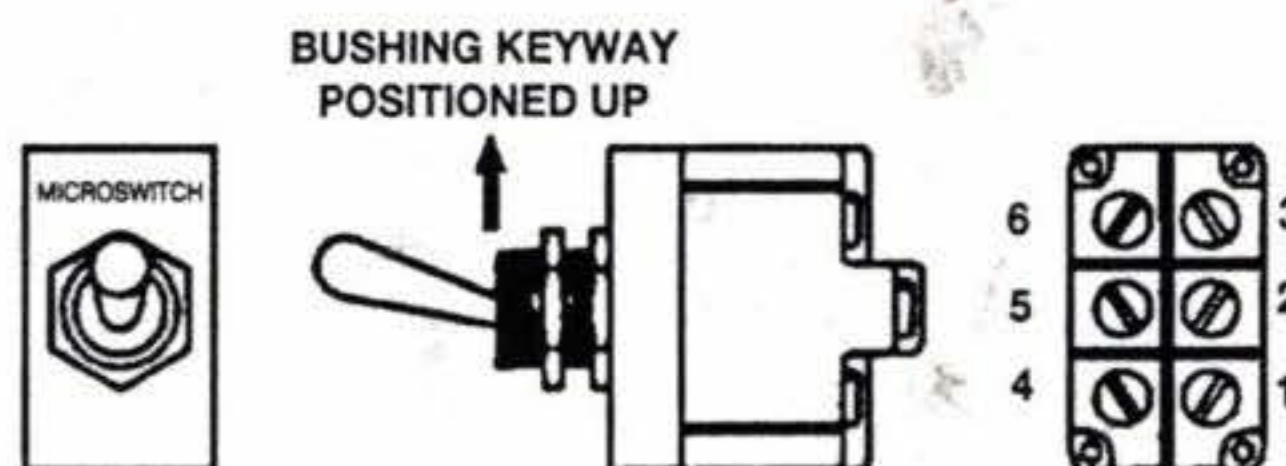
A magneto without impulse coupling should be OFF during cranking. The traditional key-switch should be fitted with a jumper between the "R" magneto terminal and adjacent "GRD" terminal (see -View A- in Figure 1). The GRD terminal is internally configured to ground the right mag lead wire when the key-switch is in the START position. If your switch does not have a START position, just OFF, LEFT, RIGHT and BOTH, then a jumper and extra GRD terminal will not be present. If you have a mags-only key-switch then it is essential that you know if your engine is fitted with two couplers. Engines with two couplers may be cranked with the mag switch in BOTH. If only one coupler is present (usually on the left mag) then the engine should be cranked with the switch in LEFT position.

The possible consequences of improper wiring, malfunctioning switch or improper procedure are as follows: If a non-impulse-coupled magneto is "hot" during any portion of low speed rotation, it can deliver a spark some time before top-dead-center. Albeit a weak one, this spark has been known to ignite a mixture in the cylinder forcing the engine to "kick backwards." If this occurs while the starter is engaged, very large forces are placed on the starter ring gear, starter drive parts and starter casting. It is not uncommon for one or more of these parts to break. If kickback occurs while hand propping the engine the result can be unhappier yet. New, stouter batteries and aggressive, lightweight starters exacerbate this problem. An engine that cranked at 70-100 rpm

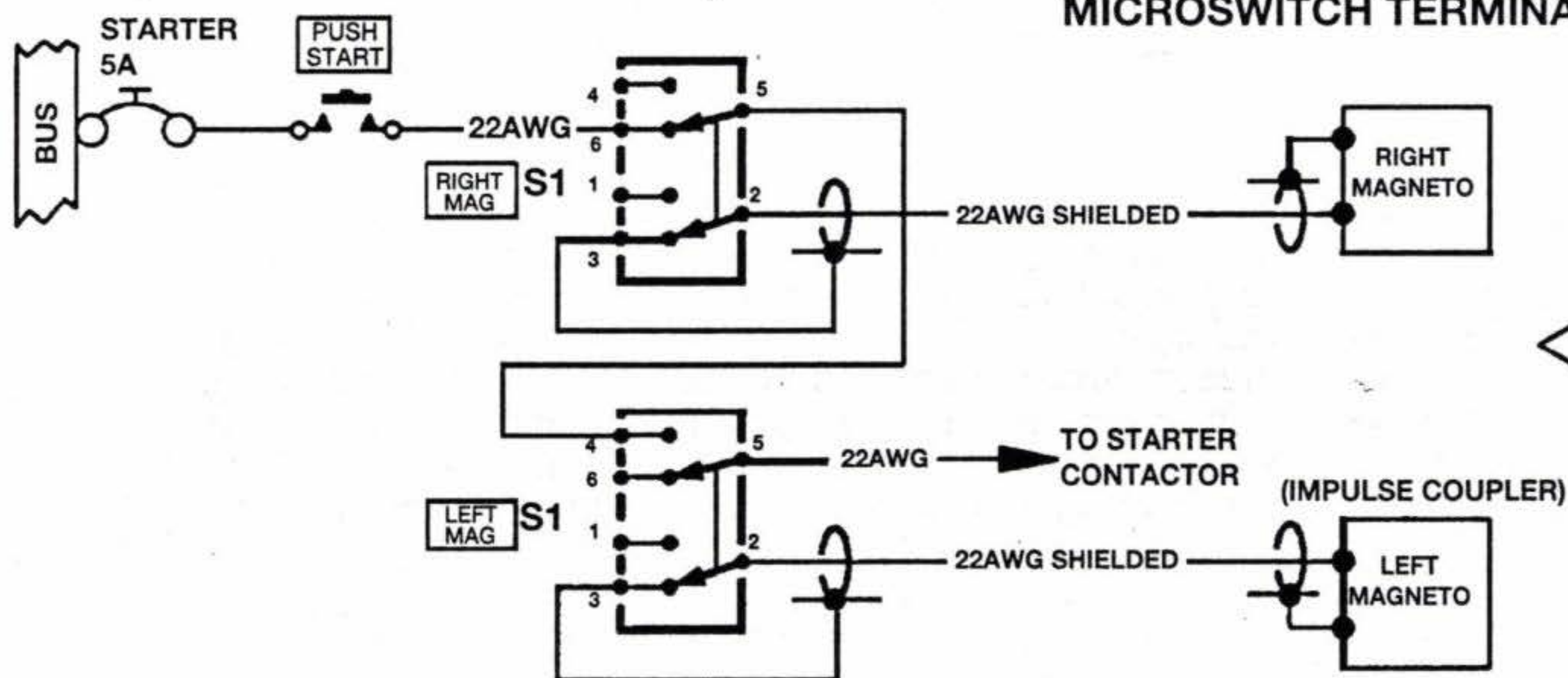


THERE ARE TWO (2) "GRD" TERMINALS ON ACS A-510-2 SWITCH "GRD" ADJACENT TO "R" IS JUMPERED TO "R" TERMINAL TO PROVIDE RIGHT MAG DISABLE DURING ENGINE CRANKING

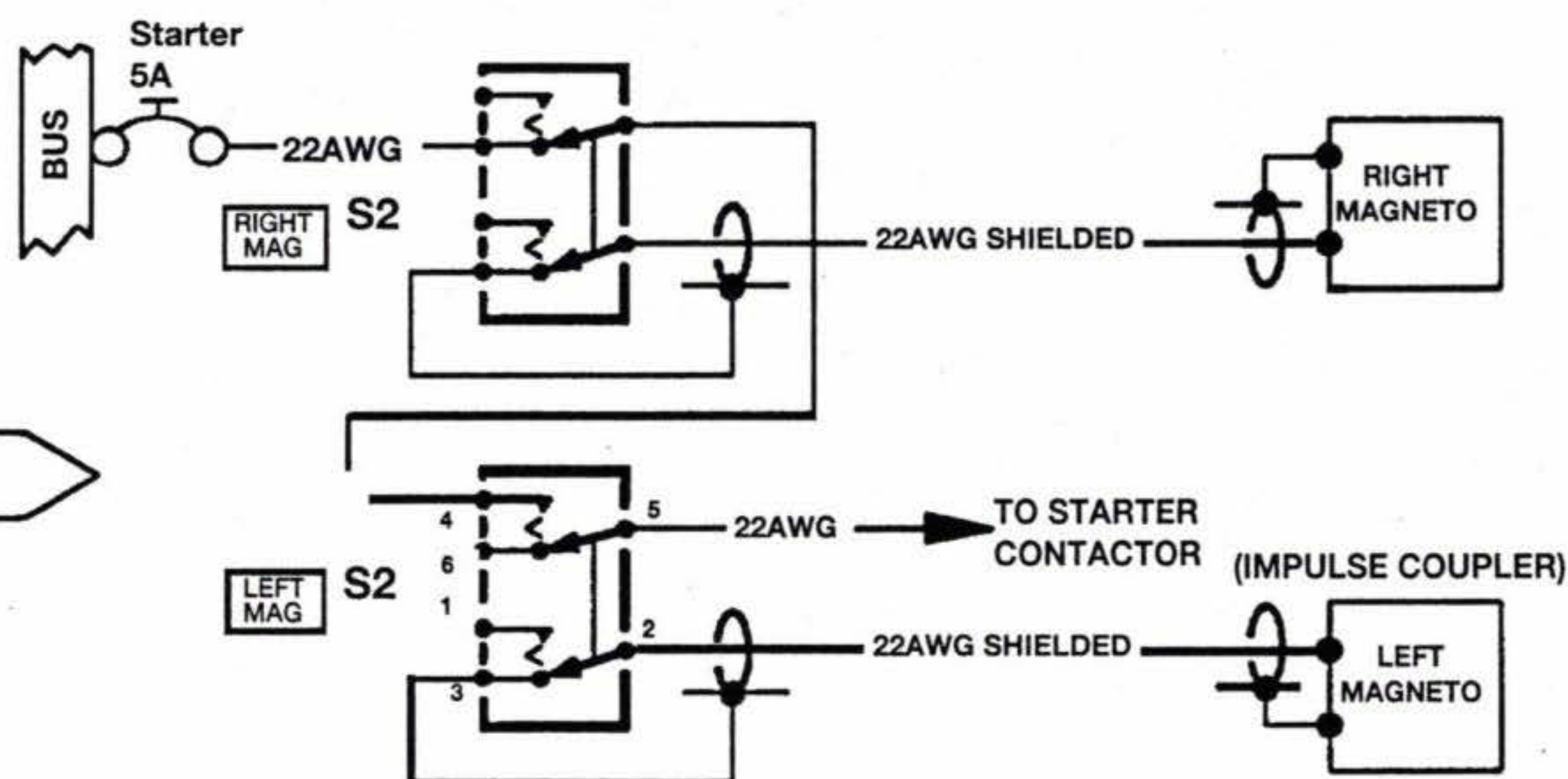
SUGGESTED NUMBERS FOR TOGGLE SWITCHES
 S1 - MICROSWITCH 2TL1-3 (MS24524-23) OR EQUAL
 S2 - MICROSWITCH 2TL1-5 (MS24524-31) OR EQUAL



MICROSWITCH TERMINAL NUMBERING



-VIEW C-



with older starting components may crank at 100-150 rpm with newer parts. The likelihood of getting an adequate spark from a non-coupled magneto goes up sharply as cranking rpm are increased.

Modern cranking components are causing a new problem to occur. Let us suppose that you have been cranking the engine without getting it to fire for several seconds and have just decided to stop for things to cool off. If, at the instant you release the key-switch back to BOTH, the mixture in the next cylinder up for firing decides to get exactly right, the inertia stored on the propeller carries the engine through magneto firing and kickback occurs. It's a roll of the dice . . . it doesn't happen very often . . . but IT DOES HAPPEN. The consequences can be expensive.

The best fix would be to redesign key-switches to an OFF-RIGHT-BOTH-LEFT-START pattern. This would prevent the right mag from becoming hot while the engine is still in motion at low speed. The likelihood of anyone redesigning the key-switch is slim to none so consider this alternative. Toggle switches are readily available with two-pole, double-throw action. Two such switches are

shown along with a START push-button in -View B-. Wired as shown, the starter circuit is disabled if the right magneto switch is not in the OFF position. You can also purchase toggle switches with a two-pole, double-throw, center off action with a spring return to center from one extreme. This arrangement shown in -View C- permits the left mag switch to double as a starter control. Again, the cranking circuit is inhibited if the right mag switch is anywhere but OFF. Rotary key-switches are more expensive than toggles and they provide only a modicum of protection against theft . . . if anyone really wants your airplane, AND they know how to fly it, a key-switch will present only a small inconvenience in achieving their goal. Toggle switches "look" like they belong on the panel with all the other switches and they don't require you to struggle for keys still in your pocket after you've strapped in! Best of all, they provide a wiring option which eliminates a common cause of damage to engine components.

One final point. Note that I show shielded wire between the magnetos and the mag switches. Spark plug wires and magneto p-lead wires are the ONLY wires which should AL-

shields should be grounded to the airframe/engine only at the engine end. The shield is used to provide a ground for the "GRD" terminals at the switch but no other connection to the shields should be made at the instrument panel end. Noise sources, noise victims and noise propagation control is a large topic for another time. For now, understand that shielded wire has limited capability to reduce only two of four common noise propagation modes in vehicular power systems. Shielding of most other wires in an airplane, unless recommended by equipment manufacturers, is unnecessary.

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